Surface Modification with Lasers and Electron Beams

Unique fabrication and characterization capabilities

We have laser-beam and electron-beam processing facilities for developing

- Stoichiometrically controlled thin-film coatings
- Wear- and corrosion-resistant surfaces on metals
- Electrically enhanced layers on ceramics.

When fabrication is complete, state-of-the-art science and materials characterization capabilities are available for analyzing the quality of the fabricated thin films and surface-modified layers.

Thin-film deposition by laser ablation

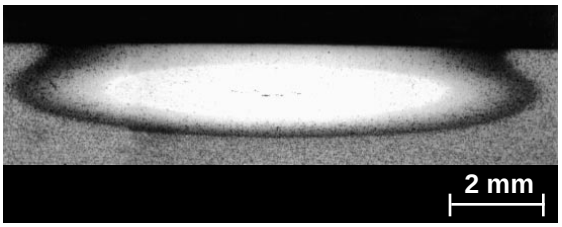
We perform laser ablation of high-purity target materials to deposit thin films on substrates. We deposit thin-film, metal-oxide perovskites, such as $YBa_2Cu_3O_7$ for high-temperature superconductor and ferroelectric thin-film applications with excimer lasers in an oxygen-bearing atmosphere. We perform electronic-structure measurements and theoretical calculations of the deposited crystal structures on these films to model the influence of crystal structure and chemical composition on their physical properties. Using Lawrence Livermore's copper vapor lasers, we are investigating high-deposition-rate laser ablation techniques for coating large areas with smooth, diamond-like carbon films. These films have superior thermal, electrical, and wear-resistant properties.

APPLICATIONS

- *High-temperature superconductors and ferroelectric thin films*
- *Enhanced electrical conductivity on insulating ceramics*
- *Localized heat treating of steels*
- *Coating of large surface areas with diamond-like carbon films*

Laser melting and chemical reactions

We can perform surface melting and alloying to depths of up to 1 mm to create unique, metastable phases through the rapid solidification (~10^5°C/s) that occurs during processing. We have performed laser-enhanced chemical vapor deposition with an excimer laser to create a 1-µm-thick layer of TiC on a titanium alloy—a procedure developed for localized repair of scratched or damaged TiC coatings on titanium alloys. We can use high-brightness copper vapor lasers to write lines with enhanced electrical conductivity on insulating ceramics, such as AlN, and can produce line widths more than 10 times thinner than those produced by conventional laser-writing technology.



Transformation-hardened zone in O-1 tool steel using a localized 10-mm-diameter, 6-MeV electron beam. The transformed steel reached peak hardness without melting the surface.

Electron-beam processing

We can perform electron-beam surface melting, alloying, and heat treating using conventional and high-energy electron beams (HEEBs). Conventional electron beams are coupled with custom-designed electronics to produce a variable-frequency and variable-waveform scanned-line source that can be rotated to cover a large circular area (5 cm^2) with a uniform energy density. We have performed localized heat treating of steel using a pulsed, 6-MeV high-energy electron beam to produce a 2-mm-deep hardened layer in steel without surface melting. This beam allows deep and instantaneous penetration of the electrons in steel at energies of 300 J, making it ideal for rapid thermal processing of materials at heating rates up to 10^{10}°C/s.

Availability: These processing facilities are operational now. We are seeking partners to collaborate in developing new applications, materials, and surface-treating techniques.

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